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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

GENERAL INSTRUCTIONS TO CHIEFS OF PARTY
FOR
LOCATION SURVEYS
ON
NATIONAL FOREST ROADS AND NATIONAL PARK ROADS

1926

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WASHINGTON
GOVERNMENT PRINTING OFFICE

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For use on national-park projects the following alterations are to be made:

1. Wherever the word "forest" appears, the word "park" shall be substituted.

2. On page 26 the paragraph "Title sheet" shall be modified as follows:

The fifth and sixth lines to read "* * * district engineer and park superintendent * * *."

3. "*General.*"—It is expected that the landscape engineer of the Park Service will investigate the route during the period of preliminary survey. The chief of party shall assist in every way possible and shall follow suggestions made by the landscape engineer in so far as they are in accord with previous instructions. A report of the landscape engineer's recommendations shall be submitted to the district engineer, and any of his suggestions not in accord with previous authority given the chief of party shall be given special attention.

Special consideration shall be given to scenic features and to the preservation of vegetation and avoidance of landscape scars.

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GENERAL INSTRUCTIONS TO CHIEFS OF PARTY FOR LOCATION SURVEYS, NATIONAL FOREST ROADS

GENERAL

The district engineer will designate by letter the chief of party, who shall, before leaving, (a) acquire complete information regarding the project; (b) collect an approved list of equipment; (c) select his subordinates with the advice of the district engineer.

(a) The papers concerning the project will include the district engineer's letter, the standard national forest road specifications, the cooperative agreement (if any has been executed), and such township plats and descriptions of corners from the United States Surveyor General's Office, the Land Office, or the Forest Service headquarters as will be found useful.

The district engineer's letter will describe the project in respect to exact location, length, termini, width, standards, including grade and minimum radius of curvature, and give (reconnaissance) estimate of cost of both survey and construction, including a copy of the reconnaissance map and report if such have been prepared. The letter will state the modifications, if any, of the standard survey methods that will be required, and also will give pertinent information regarding the location and elevation of any United States Geological Survey benches, maps, etc., the vertical control extension required from the survey, the desired make-up of the party and rate of pay, per diem allowance, etc. The letter shall include necessary instructions regarding rights of way.

The chief of party will consult his immediate superior concerning any doubtful points in regard to the fiscal regulations, transportation, reports, salaries, expenses, etc., and will take a supply of all necessary forms (see Location Survey Equipment

Check List, Including Forms Listed With General Office Supplies, p. 27), particularly Form F. R. 57. The General Instructions for Field Cost Accounting, Reports, and Forms for National Forest Roads should be strictly followed. Other data necessary for a complete understanding of the purpose to be served by the road, its relation to existing systems, etc., will be found in the files.

The district engineer will instruct the chief of party regarding photographs required.

(b) A list of equipment will be determined by standard procedure already existing in the office of the district engineer. (See Location Survey Equipment List, p. 27.)

(c) The number of men in a party for location surveys will vary from 8 to 12, including chief, draftsman, and cook. There shall be a field draftsman with every party. At least three temporary employees should be obtained for the party if possible in the vicinity of the job. Paragraph 450 of the administrative regulations states that temporary appointments may be made without civil-service certification to positions authorized by special civil-service regulations for the field season, such as rodman, flagman, stakeman, chainman, mechanic, and skilled labor engaged on construction work at places remote from the cities where there are local and district secretaries.

At times it may be necessary to employ additional temporary axmen, and good judgment must be used in selecting such help to avoid any delay of the survey.

PROCEDURE

The chief of party and one other man will usually precede the party into the field to prepare for subsistence and plan the work. Equipment will be brought up by the balance of the party. The chief of party will be responsible for the economic subsistence of his party and will be required to determine (if previous reports do not determine) whether or not economy demands the establishment of a camp or camps or the use of local ranches for boarding houses. He will personally supervise the ordering of supplies. The first duty of the chief will therefore be to arrange for the subsistence and transportation of his party, and he should determine as quickly as possible

the best means of transportation. He will designate the organization of the transit and level parties and see that each man is used to the best advantage for the prosecution of the survey. He will personally be responsible for handling of all right-of-way matters in the field. He will see that field plans keep up with the field work and that the survey at all times is making satisfactory progress. When necessary to reduce the party the topography section will be dropped and the work of the topography party postponed temporarily. He will report his mailing and telegraphic address at once with advice as to the best route for inspectors to reach his headquarters, will promptly answer all letters from the district engineer, and keep all reports up to date and forward same promptly.

National forest road surveys will be made by one standard method described below, but this standard may be modified by the district engineer when in his judgment the standard of proposed construction or the probable postponement of the project make modifications desirable. The principal modifications that will be required are also described below. All location survey work in the field will be subject to the inspection of an immediate representative of the district engineer, who will act as chief locator.

FIELD OPERATIONS

General Provisions.—The controlling points indicated by the reconnaissance survey should be verified and thoroughly investigated for the entire line before the survey starts. The controlling elevations and the allowable grades establish a basis for the required development. In addition to such features, right of way and use of portions of existing roads may finally affect the choice of parts of the located line, and the chief of party should bear this in mind in his first investigation. The district engineer will give instructions to the chief of party as to any modifications of the standard survey type, and may require an inspection and a report from him before deciding.

Transit Lines.—In all cases measured lengths along the transit lines should be horizontal and accurate, breaking chain as found necessary. Stakes should be purchased at a sawmill and not made by the party, except in emergency or where delay to

the party would result. A standard stake approximately $\frac{3}{4}$ by $1\frac{1}{2}$ by 18 inches is recommended, and should be driven about 9 inches at every 50 or 100 foot station.¹ At transit points 2 by 2 by 8 inch hubs (with tack and guard stake) will be driven and will be triple referenced by transit ties to permanent objects, also at points not greater than 1,500 feet apart on a single course. When no suitable trees are available for references, large stakes may be used. Transit bearings, turned on trees or other permanent objects, are often of great value. Reference points must in all cases be secure from any disturbance occasioned by clearing and grubbing or other operations incident to construction. The chief of party should in general take charge of the axman and precede the balance of the party brushing out line and determining grades with a hand level.

Angles will be measured either as deflection angles and doubled for check or as azimuth, using in each case a true meridian determined from Polaris or sun observation and checked approximately every 12 miles by new observation. Courses should also be checked by a compass reading.

In locating all transit lines the chief of party must bear in mind the general control, standards of grades and curvature, the classification of materials, and the probable excavation involved.

In heading sharp gulleys particular care must be taken to furnish sufficient information for at least three tentative lines in the design to determine to what extent economy demands that the adjacent shoulders shall be cut and to what extent the corresponding fill across the gully may be increased. The chief of party will be responsible for location of his line in such a way as to take advantage of all benches and flatter slopes, and must secure sufficient information by cross sections or contours to determine the design in this respect before leaving the field.

Notes.—The record of the transit line in the notebook should follow standard procedure (see sample). The notes should be kept from the bottom of the page upward, with necessary

¹ Fifty feet in rough country or where brush or down timber is present. In rare instances distances of 200 feet may be staked on surveys for light construction in open country.

sketches on the right-hand page. When beginning a notebook it must be properly inscribed in ink with name of the State, forest, county, and project. For each day's run the notes, including list of party, weather, and date, should be signed by the recorder. Loose-leaf standard notebooks will be used only when specifically ordered by the district engineer to facilitate field drafting.

In addition to the standard topographical features, the transit notes of the adopted line will show the extent of clearing necessary by stations and specify its character, as pine, fir, etc., whether heavy, medium, or light. (See clearing classification.) The sketch on the right-hand page will show the outline of all visible rock and dot line the probable rock. Classification in the field will be checked by two independent observers and finally checked by the chief of party. Test pits will be dug or holes drilled in doubtful cases. Classify as loose rock all material averaging greater than 6 inches and less than one-half cubic yard.

Topographic Data.—The field work must be done with care and adequate notes recorded in the field book to insure a satisfactory design of the project. This will include the station and bearing or deflection of intersecting boundary lines of national forests, townships, and counties, also ties to frequent section lines and ties to the two section corners nearest to the point where the traverse crosses the section line when any right-of-way trouble is involved. Roads, railroads, property lines, existing drainage structures, proposed location of guard rail, culverts, riprap, retaining walls, new drainage, special foundations, and the location of road-building material, such as gravel, stone, sand, bridge timber, sawmills, cement-pipe factories, will be entered in the notes, giving station, distance, etc. Drainage surveys will be required for openings exceeding 20 feet in span; if United States Geological Survey sheets or other reliable maps are available, this information may be sketched from them for the plans; but all data required on the standard form for bridge design must be secured, especially data for foundations. For crossings greater than 50 feet or for steep approaches the bridge data must be sufficient for a 20-foot scale contour map.

Notes should also contain recommendations with reasons by the chief of party as to the size, design, and material (concrete, corrugated pipe, log culverts, or stone masonry, etc.) of drainage structures at all necessary points, and the possible source of supply of construction material and kind. Special record must be made of the location, quality, and quantity of all road-surfacing material, and the sections of the project which will probably require use of the same.² The transitman will check his notes each evening.

Right of Way.—The chief of party himself will interview all property owners and will locate his final line where topography, drainage, and natural economic features require, but at the same time he must endeavor to avoid objections of owners and be scrupulously courteous in his contact with them. He will obtain all names and addresses of owners of such tracts as involve taking and will endeavor to secure such releases as prescribed by the district engineer for any particular State or county. Some cases of right of way may require running out section lines and property lines, and in open country a 300-foot tape or transit and stadia may be used; the chief of party will report any considerable cost of such work separately on Form F. R. 57. The chief of party must impress upon all owners that in no case will the Government pay for any right of way whatever; nevertheless he must endeavor to ascertain the amount of damage likely to be demanded and record such information. When required he will prepare such special right-of-way maps either as a separate small-scale map or on the standard plan as directed by the district engineer.

Levels and Grades.—See that the level is in adjustment and insist on rapid level set-ups. Refer elevations to United States Geological Survey or railroad bench marks, or, if not available, establish datum by aneroid and state clearly in each case how datum is established. Establish bench marks, approximately every 1,000 feet, on trees or other permanent objects off the right of way, which will not be disturbed

² If there is any question as to the quality of material for surfacing or choice of more than one local supply, then 50-pound samples, clearly marked, shall be submitted to the district engineer.

during construction of the road. When possible avoid the use of pine and fir trees, as the gum obliterates the scribing on bench marks.

To extend general vertical control of known elevations, make special effort to reference all bench mark elevations to sea level through United States Geological Survey benches or from Coast and Geodetic Survey benches or from railroad profile and set temporary benches each mile and use permanent benches³ every 6 miles, thoroughly referenced, and report same in special memorandum to the district engineer.

Levels should be checked in all cases by running a double set of turning points by the level party, or by a flying line of bench levels by either party. Check levels on bench marks can be run when the profile of the staked line is run or on base-line portions of line while land ties are made. Read the rod to hundredths on T. P.'s and bench marks (with target) and to tenths for profile or sections (without target). Take sufficient levels at connecting roads so that estimate for suitable intersections may be made. Levels on all final lines must determine elevations of top of opening and flow line for all culverts and crossings.

In all cases the chief of party shall endeavor to run the field line at least one-half of 1 per cent below the maximum grade in broken country, provided that this will not materially increase the length; 1 per cent below the maximum is preferable in very broken country, as slack grade will prove economical in working up the design. On all curves of less than 200-foot radii, grades should be reduced below the maximum established grade and preferable below the adjacent grades on tangents. This reduction should be as much as can be accomplished at a reasonable cost and should be sufficient for curve compensation and future changes in alignment involving reduction in length of line. For radii greater than 200 feet no reduction is required. Standard level notebook practice will be required. (See sample on pp. 36 and 37.)

³ Copper nail with copper washer in wooden bridge is an example of a temporary bench, and 2-inch galvanized iron pipe 30 inches long and set 24 inches with crow-footed base and metal cap stamped with steel die is an example of a permanent bench. Solid rock is better; use a carriage bolt cemented in drill hole.

Cross sections shall be taken a sufficient distance on both sides of the line to permit minor changes of alignment, if necessary, and to insure that cut and fill slopes fall within the measured area. Cross sections must be taken at right angles to tangents and on radii lines of curves; notes must indicate approximate slope beyond last reading recorded and approximate horizontal distance to the end of such slope.

Cross section work must never be slighted on account of its difficulty. Quantities are heaviest where work is most difficult and, therefore, the greatest accuracy is essential under such conditions.

Cross sections will be taken with a Wye level and rod only where ground and cover permit rapid work by such method. The standard method of cross sectioning will be to use a hand level and a light 10-foot level rod, reading to feet and tenths. Measure distances from the line horizontally, either with this rod or with a metallic tape, and record readings for each setting of the rod. Horizontal measurements will be to the nearest one-half foot and rod readings to the nearest tenth. In exceptional cases for preliminary data only where slopes are uniform, and when specifically instructed by the district engineer, cross sections may be taken with an Abney level, offset measurements being made parallel with the ground. Special care is required to check parallelism of tape and ground. When using this method slopes may be recorded in degrees or percentage. It is desirable to enter ground elevations instead of rod readings in the cross-section notes.

Safeguard the rodman with a rope on steep cliffs.

Cross sections will be taken at all stations and at such "breaks" of ground as may be necessary to obtain accurate quantities. At all stream crossings a section should be taken in the bed of the stream to determine flow line, headroom, etc., but such section shall not be used for prism quantities. On very light construction in even country, sections may be taken at intervals not exceeding 200 feet, where such work may be done by turnpiking.

The cross-section party should check all station numbering and should bear in mind that they have much responsibility in the classification of materials. The rodman must furnish

the recorder with accurate information. The notes must determine, in addition to careful classification, the kind of rock encountered, whether suitable for walls and abutments, also existing cover over ledges. Special sections for drainage purposes will be taken as needed for adequate information.

Contours.—In making a survey through very rough country, contours may be taken at 5-foot intervals by any standard method in lieu of the cross-sectioning method hereinbefore described. A method in common use is to employ a hand level, tape, and rod (or measuring rod equipped with levels). A three-man party—topographer and two helpers—is required. The topographer stands at the station (say, elevation 103.4) and records the distances to the even contours both ways. Assuming the height of eye of the topographer as 5 feet, the first uphill rod reading of 3.4 feet puts the head rodman on the 105-foot contour. The two helpers then advance up the hill at 5-foot elevation intervals. On the low side the man standing at the station must read 8.4 feet on the rod to put the head rodman on the 100-foot contour, and the distance out is recorded. The head rodman will carry the tape (or special rod).

Variations from this method can be made according to the judgment of the engineer. To keep horizontal distances from line recorded as total distance from the station instead of between contours, the rear man can pick up the tape each time at the previous reading given by the rodman. Under favorable weather conditions plotted sections of the transit line can be taken into the field on a small drawing board, and when oriented the contours may be plotted directly to save transferring the data from the field book.

In country broken transversely with the line take levels at all the breaks. Cross sections at these breaks are later to be plotted for quantities.

STANDARD METHOD FOR LOCATION SURVEYS

General.—National forest road location surveys will be made, unless otherwise directed by the district engineer, on a basis of final center line staked in the field before the party leaves. By a final line is meant not a line to remain absolutely unchanged, but one which will be fixed within such narrow limits

as to insure construction being kept within an ordinary width of right of way. In a rough and broken country, or where long supported (or sustained) grades are required, a preliminary line will be necessary, and a paper projection will be made to determine properly the location of the final line.

Preliminary Lines.—Preliminary lines should be run accurately in order to have correct data for the paper projections. A contour method is especially recommended in rough and difficult country and on maximum grade. Run levels carefully (with bench marks at least every mile) over all preliminary lines, which data are to be used later as a check on the final location levels. The elevation of all turning points should be carefully recorded in preliminary notes.

Where, as in fairly level or open country, the final line may be selected without preliminary line, the transit line will coincide with the final location and will be either staked and recorded with the same care as specified for the latter or will result in a projected line designed in the field and verified with check measurements to the transit line in the field. (See below.)

Working Plans.—When a preliminary line is run out and used to prepare a map from which the locating engineer can make a paper projection, the field draftsman shall first plot and check the preliminary line for each day's run from left to right on detail paper 18 inches wide to a scale of 1 inch=100 feet (in some cases use 1 inch=50 feet to better advantage) and ink in with a fine red line. All transit points will be marked by a small circle or triangle and whole stations numbered at intervals of 5 and 10 and also all P. I's. All transit lines will be plotted by coordinates.

When proceeding by the standard survey method (see later) in every case where the topography of certain sections of the country is such that the locating engineer can lay down the final located line on the ground without the use of preliminary lines, the draftsman shall plot completely the plan of such portions as prescribed below under "Office Plans." The working plans for all preliminary lines will be retained and filed with the notes as part of the records.

Preliminary Profile.—Before study can be made of the correct location of the final line a rapid preliminary profile must be

plotted. This profile is to be used as a guide and scales of 1 inch = 400 feet horizontally and 1 inch = 20 feet or 40 feet vertically should be used. On this profile will be laid down a trial grade line. This profile should be made on the day it is taken, so the locator can see if he is within his grade requirement before he leaves the locality.

Since necessary data for study will already have been shown on the working plan, the preliminary profile will consist only of a ground line and trial grade line. After the center line is located and the working profile prepared the preliminary profile may be laid aside.

Preliminary Cross Section.—Where, instead of contours, cross sections are taken to aid the locator in establishing the final center line, they shall be plotted on separate sheets to any scale convenient for study. Since no quantities are to be based on them save in a general way, no refinements in this plotting are necessary.

Final Located Line.—The working plan from the preliminary line with contours (or with preliminary cross sections) and preliminary profile, with trial grade line having been prepared, the approximately correct position of the final located line may be determined. This location line shall be one on which quantities may be balanced as closely as the nature of the country permits and a line on which right-of-way acquisitions may be based with certainty. It will be largely the result accomplished by the chief of party in the field from a careful study with the preliminary profile and working plan in hand. The line will require due consideration of future requirements of the road and will avoid danger points in contemplation of the probable increased traffic. On projects requiring hand work, long hauls are to be avoided, and it is to be remembered that heavy steam shovel cuts require one-way hauls. Great care will be taken on side hills. As soon as each section of the final plans is completed the chief of party will take the plan into the field and again compare it with the ground. This final line will be, in short, a well-studied line laid down in accordance with standard transit-line procedure and completely staked, including curves.

Cross sections on the staked center line shall be made as directed under "Field Operations."

Modification of Standard Method of Location Surveys.—Whenever (*a*) the type of proposed construction, (*b*) the nature of the ground and cover, or (*c*) the probable postponement of actual construction, in the judgment of the district engineer, demands that modification be made in the standard type of location survey, written directions shall be issued to the chief of party. As pointed out above, in order that he may be fully informed as to the desired modification, the district engineer may first require a special field report from the chief of party.

The principal modifications permissible will be:

First.—A changing of the entire method to a base-line or transit-line survey with field-office projection for the entire final located line. This method will, in general, be permitted only where it is possible to run the base line within 5 or 10 feet of the proposed center line, and where time and size of party will permit working up the projected line in the field. In this case a field check of measurements from the base line to the projected line will be made at all critical points or sections before the party returns to headquarters. In running survey by the base-line method all curves with total deflection angles greater than 20° shall be staked in the field as projected and sufficient ties made with the adjacent projected line, also necessary station equations noted. Contours will usually be required for locating curves and projecting the line at all heavy-cut sections or difficult ground along supported grade. If in exceptional cases excessive cutting and brushing is required in order to permit the staking of curves, the district engineer may order such staking to be omitted. In this case for deflection angles greater than 30° short tangents and additional P. I's shall be used to fit the line closely to the ground.

The above modification will usually occur where it is necessary to curtail the expense of the location survey. It is understood that the corresponding expense of field engineering on construction will, however, probably be increased. If the date of beginning of the proposed construction is uncertain and distant, also if the type of construction is very light (for example, for a project less than 12 feet wide or for a turnpike job), the base-line type of survey will generally be required. On extremely light work a 200-foot steel tape may be used and a pre-

liminary type of profile run with cross sections at approximately 200-foot intervals.

Second.—Under the standard location survey procedure with a staked center line it may be found, particularly in the northwest coast areas, that the density of forest cover interferes with the complete staking of the line. In such cases, on certain intervals of the survey, a base line with projection will be permitted, provided that projection is checked in the field.

Third.—In open country where the question of projection is of secondary importance the transit or base line may at once become the final staked center line, without recourse to a preliminary or working plan or profile.

Whatever modifications of the standard location survey are used, the final profile shall be compared with the ground by the chief of party as a last field check before proceeding to the headquarters office. If possible, he should be accompanied by the bridge engineer to check the layout, prepared design, and tentative estimate of major structures, including retaining walls.

If any part of a staked center line needs to be rerun, this shall be done in the field if possible, otherwise suitable notations shall be made on the plan and in the transit notes to indicate clearly what is required to identify exactly the portions of line to be restaked.

DESIGN AND ESTIMATE

General.—Design procedure will include all field and headquarters' office work from the plotting of the first preliminary line to the completion of tracings, estimate, and specifications. The cost of national forest roads depends largely on the excavation required. The location and design of the road determines this required excavation. The importance of both is, therefore, evident. The object of a final staked location line in the field is largely to improve the design. The final corrected design of line and grade must show economically balanced quantities with suitable allowance for shrinkage, super-elevation, sloughing, and erosion of banks, and must at the same time present acceptable curvature and grade.

It is to be remembered that side-hill gradient may be a less determining factor than alignment, and that slight alteration in line may greatly affect the quantities. Also, on side hills the design must be stable. It must not be assumed that a down-hill slope will hold a fill if the field data do not clearly so indicate.

Before proceeding with the design read carefully the National Forest Road Specifications.

Office Plans.—The directions for preliminary or working plan for standard procedure have been given. Similarly, the office plan of the final transit line shall be plotted daily in black ink from left to right on 22-inch detail paper. The standard scale will be 1 inch = 100 feet, and stations will be numbered at such intervals as directed under working plans, and all full stations shall be noted with a $\frac{1}{8}$ -inch crossline. In exceptionally difficult or rough country a scale of 1 inch = 50 feet may be required for the entire line or for portions thereof. For light construction (such as grader work) in exceptionally open country or for other specific reasons a scale of 1 inch = 200 feet, for the office plan may sometimes be authorized by the district engineer.

The office plan will be the record of the topography, the design and staked location resulting from the careful field survey and study of the preliminary working plan, including contours, profile, and cross sections, which, as heretofore stated, should be compared by the chief of party with the ground before leaving the field. On this plan will be the record and dimensions of all proposed construction.

Proposed structures must be shown with great care. Pencil while in the field (in writing if not to be traced) on the detail sheet of plans sufficient notes to indicate availability of material for structures and all other data for the designer at the headquarters' office. Show direction of stream flow by arrow; make liberal notes as to forest cover, soil, rock slides, walls, special drainage, etc. In flat country sizable boulder material for paving fords of small streams is desirable. In certain drainage areas clean boulders are present and permit the use of class D concrete and the location of such material should be recorded. The location and amount of sand, gravel, etc.,

which may be used for surfacing or for concrete should always be given.

The length of culvert is important; it must be sufficient to permit placing on solid ground at the bottom of the fill and may best be determined by plotting an accurate cross section. Reduce the number of headwalls (if necessary to extend pipe) on downhill ends of pipe culverts. Uphill headwalls should be set clear of any possible obstruction to traffic. (See sheet of standard culvert design.) Data on the field plan should indicate whether or not corrugated metal culverts are desirable. Commercial lengths of corrugated metal culvert vary by 2 feet. The use of 30-inch diameter as a maximum should, in general, be adopted, although 36-inch diameter pipe may be used in special cases.

All structures of span greater than 20 feet are to be designed by the bridge engineer and masonry or concrete abutments will be required. All other structures will be in accordance with standard designs. To facilitate design sufficient information on the bridge data sheets must be forwarded promptly to the district engineer as fast as the final located line develops. The bridge engineer and the chief of party should ultimately make a joint examination in the field with the finished structure designs in hand. On this inspection the size of opening and headroom of all larger culverts will again be checked.

In designing trestle bridges it is to be remembered that concrete mud sills increase the life of such structures and are adapted for plank abutments for small bridges in dry country. In general, retaining walls are to be avoided and the use of dry wall is discontinued entirely except as hand-placed embankments.

Hand-placed embankments will be constructed only under first-class conditions for supporting foundations and then upon carefully prepared footings. In this construction the embankment will be made in horizontal layers. All that part of the embankment beyond a perpendicular at the shoulder of the roadway will be hand placed. The entire embankment will be of rock. For heights up to 10 feet, hand-placed embankments will be constructed with a batter never steeper than three-fourths to 1 and with a batter never steeper than 1 to 1

for greater heights. All wall designs should be specially checked in the field by the bridge engineer when checking structures.

The final plans of all structures shall be, as far as possible, standard plans and should require a minimum of new designing or detailed estimating.

Office Profile.—The standard profile shall have a horizontal scale of 1 inch=100 feet and a vertical scale of 1 inch=10 feet. On all standard location surveys there will also be first prepared daily a working profile of the final line as it progresses on a horizontal scale of 1 inch=400 feet and 1 inch=20 feet, or 40 feet vertically. On this working profile a tentative grade line shall be established and a field study made by the chief of party. He shall, in the field, note on the working profile the classification of excavation, all drainage, class of clearing and grubbing, etc.; also make a careful eye check of the grade line, noting necessary changes for clearance, elevation above swamps, and other unusual conditions not determined by office study. He should note special structures, guard rails, walls, cribbing, with pertinent information, and particularly high and low water, and, in short, obtain in condensed form complete information for field use, office profile, and correction and amplification of office plans. Notes on this working profile shall be entered in the transit notebook at the end of each day of field study.

The ground line of the standard office profile shall always be checked and inked in black before the pencil grade line is drawn. Ground lines shall be drawn straight from one elevation to the next. The line stations at sufficient intervals should be clearly inked and the stations of grade intersections shown in ink with suitable bold figures. All elevations of ground and of old and proposed flow line of culverts must be shown; also the elevation of bridges and stream bottoms, railroad crossings, drainage structures when paralleling highways, etc. Any pertinent notes found in the level books or on the working profile regarding foundations for structures, soil, cultivation, rock, intersecting highways, villages, etc., should be briefly shown on the office profile. The lengths and the corrections of vertical curves shall be shown, and the grade line for the entire length shall be finally adjusted and approved by the chief of party, and

elevation of intersecting points of grade and per cent of grade shown.

Where the base-line method has been used, it will sometimes be advantageous to spot the elevations of balanced cross sections on the profile before adjusting the base line, and the process of designing the grade will, of course, be otherwise suitably modified, usually involving more lateral adjustment of the base line.

For standard-location surveys or for base-line surveys that result in a projected center line from the base line, checked in the field, a quantity diagram of excavation may be found of considerable value. This quantity diagram is a curve of quantities of excavation and embankment at each station, and where the line is staked in the field the diagram may be traced and printed below the profile for the information of the resident engineer.

Avoid long, level grades (except on fills) and all adverse grades when climbing to a summit. Make intelligent use of the allowable maximum grade provided in the cooperative agreement. Consult article by Ball and Short, Public Roads, volume 2, Nos. 16-17, for a practical method of grade design.

Cross Sections and Quantities.—All excavation quantities will be determined from cross sections plotted to a standard scale of 1 inch=10 feet (use 1 inch=5 feet in special cases) by average-end-area method of calculation. Plotting will be on standard Plate 3, 22 by 36 inches, or on the same plate in continuous rolls, and so arranged that rolls may be cut into standard plate size with binding margin. The measurement of end areas for the location estimate may be by one of several methods with sufficient checks. The standard method is to use a planimeter checked by occasional double readings or by calculation of triangles. Where the country has even slopes tables of quantities from center heights of standard sections may be used with corrections for gutters, or a slope diagram from similar data may be used. Care will be taken to determine stationing of all zero sections (points of change from cut to fill, or vice versa). Quantities will be tabulated by stations and finally transferred to the estimate books.

For plotting cross sections establish several heavy base lines, dividing equally the height of the paper and plot from the

bottom of the sheet upward, separating sections at least $1\frac{1}{2}$ inches, using the heavy lines at datum elevation. Show the station numbers in ink at the right of the section, and similarly the profile surface elevation, reading vertically at the proper position. When required for designing, show on sections fences, tree lines, rocks, proposed walls, etc. The ground line shall be drawn in ink.

After a trial grade line has been established on the plotted profile, the standard section will be plotted (in pencil) at center grade elevations on the inked cross sections, utilizing a celluloid templet for this purpose. When directed by the district engineer templates showing an equivalent horizontal base may be used instead of templates cut true to crown and ditch; and if tables and diagrams based on center heights and slopes are to be used, such templates are necessary. The standard templates to be used in any given case will be determined from the typical cross sections that have been fixed for the project by the chief of party after consultation with the district engineer.

Trial Grade.—When the standard location survey has been modified, wholly or in part, to provide a projected location from a base line, more lateral shifting of the line on the cross-section sheets will be required after the trial grade has been designed and trial quantities have been calculated or estimated than for the adjustment under the standard method where contours are used. When the process of shifting templates has resulted in a close balance of quantities, the new positions of the center line, so derived, shall be transferred to the plan and the center line redesigned to follow approximately the shifted points, using smooth alignment. It is then necessary to transfer any corrections from the plan to the cross sections and recompute the end areas resulting from the new position of the templates. It may become necessary to repeat this operation more than once to accomplish the final design. Attention should also be given to profile and grade changes resulting from all line changes.

In the final determination of quantities, excavation and embankment must be approximately balanced. For this purpose the shrinkage coefficient of excavated material when placed in embankment must be fixed from the best available information. It will vary from 10 to 50 per cent, depending upon the depth of the cut and the nature of the soil. Rock excavation, where

encountered to any large extent, will be assumed to form an equal volume of corresponding embankment, and grade must be so designed that the depth of fill will take the excavated rock. To balance quantities where rock is present in large amounts, first subtract the volume of rock from the total excavation and then from the total embankment and provide in the design sufficient cut to make the remaining embankment, using the suitable coefficient of shrinkage for the remaining cut. In adjusting quantities reduce the greater quantity when possible and endeavor to balance quantities within the free haul proposed (in general, from 300 to 500 feet). Arrange the haul down grade as mentioned under "Field Location"; steam-shovel cuts permit hauls only one way, but such hauls should be down hill; consequently balance points should tend to occur at summits or at the end of cuts on long grades.

If it is finally found necessary to provide borrow, this should be done, preferably by increasing cut slopes, by widening through cuts or by widening at adjacent sharp points of the alignment. Side borrow is undesirable and on side-hill roads a borrow pit below the grade of the road is not justified. Any borrow pits below grade must be so placed as to allow at least a 4-foot berm of original surface to provide for any future widening of the road. Great care must be taken on steep side-hill slopes to provide stable design. Embankment is generally unstable on slopes greater than $1\frac{1}{2}$ to 1 and the road section must be "benched in" or set into the hill to make the roadbed secure.

It is true that some fills will catch on nearly all natural slopes, but on all doubtful sections it will be assumed that no embankment catches or that all excavated material will be waste unless "end hauled." In general, it is preferable to cut deeper into the hill rather than to build retaining walls. Occasionally where sufficient suitable rock will occur on the work, hand-laid rock fills.

It will be noted that where surfacing is to be provided the templet crown will be modified to suit the surfacing proposed.

Where funds are very limited it may be permissible to design cut sections in common material of certain types as steep as 1 to 1 or even $\frac{3}{4}$ to 1, but when this is done allowance must be made for considerable slide (not less than 10 per cent; see

under "Estimate"). Standard slopes in cut are 1 to 1 in common, $\frac{1}{4}$ to 1 in rock, $1\frac{1}{2}$ to 1 in sandy gravel or wet cuts, and $\frac{1}{2}$ to 1 where rock is expected but not exposed. In designing the position of line and grade from the cross section due advantage must be taken of all slack grade shown by the profile.

Waste cuts can usually be eliminated by raising the grade bodily. The cost of borrow should be carefully compared with the cost of overhaul that will eventually better the design of the road by the movement of excavated material to widen at sharp point, etc.

On pages 39 and 40 are shown standard typical roadway cross sections with tabulations applying to sections for various widths.

STANDARDS

See page 1, third paragraph. (District engineer shall decide standards to be used.)

Standards on forest highways which form a part of the existing Federal-aid highway system, or anticipated future extensions, shall be as follows:⁴

Gradient.—The maximum and ruling grade shall be 5 per cent, except as follows:

(1) Grades up to 6 per cent may be used for distances not exceeding 2,000 feet where topography permits a considerable saving by the use of the steeper grade or where to hold to a 5 per cent grade would require undesirable development.

(2) Grades up to 7 per cent may be used for distances not exceeding 1,000 feet, but a showing of necessity for such grades will be required.

(3) For short grades in a rolling country it is desired to maintain 5 per cent as a maximum, with the grades in all cases reduced as much below this as the topography, cost, and drainage will permit.

On tangents endeavor to maintain uniform grades rather than to use choppy grades in an effort to balance quantities. But a rolling grade may be desirable where the grade tangents are long, vertical curves easy, and the gradient light; or where topography makes the necessity of a rolling grade apparent.

⁴ Standards for other major projects and development roads shall be determined by existing conditions.

The minimum length of grade tangents between vertical P. I's should be 300 feet. Where feasible, grade breaks should be on horizontal curves.

Compensate grades over 5 per cent on all curves of radius shorter than 200 feet, at the rate of 1 per cent per 50 feet reduction in radius. In location and design, consider the probable future widening and straightening of the road and lay the grade with this in view.

In general, use minimum lengths of vertical curves, as follows:

For grade changes up to 1 per cent, 100 feet.

For grade changes from 1 to 3 per cent, inclusive, 200 feet.

For grade changes from 3 to 5 per cent, inclusive, 300 feet.

For grade changes over 5 per cent, 400 feet.

Alignment.—Use the following alignment standards:

Minimum radius, blind curvature, 200 feet.

Minimum radius, open curvature, 150 feet, except in extreme cases, which must be justified by comparative estimates and topographical map showing both the proposed and standard location.

On hillsides fit alignment to the ground by long, light curvature, rather than by use of short tangents connecting curves of greater degree, and in projecting fit the curve and then connect tangents, rather than the reverse operation.

Reduced curvature and the longest possible radii compatible with the topography of the country and with economy are desired.

Where curvature is necessary, at property corners and approaches to towns and where no physical obstacle exists, use, if possible, a 1,000-foot radius as the minimum curvature and have a tangent not less than 200 feet in length between reverse curves. In rugged country the length of tangent between reverse curves will be determined by the existing conditions.

Widening and Superelevation on Curves.—Widening on curves should be determined by existing conditions, but as a guide it is suggested that the added width in feet be approximately the cube root of the degree of curvature.

Superelevation should be provided even on earth roads, and should be determined by the degree of curvature.

Roadway.—Except upon prior approval by regional headquarters or the Washington office, a standard 18-foot roadway will be the minimum on the primary system. On all other roads the standard roadway will be determined by the local conditions and needs. Prior approval by regional headquarters or the Washington office must be secured for all designs not standard.

Surfacing will in some cases be approved for less width than the width of roadway, as a 14-foot surface on a 16-foot roadway.

Bridges.—The type of bridge construction should be of a standard commensurate with the structures already built or contemplated on adjacent sections of the same route.

The clear width of bridges shall be not less than the width of surfacing, and the minimum width of roadway for bridges on the primary system shall be 18 feet between inside faces of curbs or felloe guards and 19 feet clear between handrails or truss members for a height of 9 feet 6 inches above the grade at the center line. A vertical clearance of 14 feet shall be provided above the grade at the center line for a distance of 5 feet each side of the center line.

For timber bridges, in order to eliminate waste on commercial length of floor planks, a width of 19 feet shall be provided between inside faces of felloe guards.

For bridges not on the primary system or temporary structures constructed with the expectation of early replacement, a reduction in the width above specified will be considered upon recommendation by the district engineer. Such reduction will not ordinarily be approved except when the probability of the road being subjected commonly to two lines of traffic during the life of the structure is small. The district engineer shall obtain approval of the reduction in width before the design of such structures is begun, or where plans already prepared are applicable, before submitting the plans for approval.

Where masonry abutments or piers are to be constructed they shall, except in special cases, be built with sufficient width to allow for a future reconstruction of the superstructure to the width required on the primary system, attention being given to the probable type of reconstructed permanent superstructure.

LOCATION ESTIMATE

General.—A computation of the estimate from the standard location survey plans and data will be made in a standard estimate book. In making the estimate great care is necessary in the item of classification. Some solid rock classification must be made for every project whether rock is visible or not. Where slopes on side-hill location are approximately $1\frac{1}{2}$ to 1, a percentage of rock excavation must be estimated for all such portions, to be determined by data from previous projects. It will be seen that classification in the estimate is to be regarded even more critically than refinement of measurements of end areas. There should be an allowance in the estimate after all calculations are made of 10 per cent for allowable overbreak in rock and also for slides in common, for both of which items payment may be required. Special care shall be taken to provide for the items of shrinkage of excavation in embankment, as before noted under "Cross Sections." Provision should, likewise, be made in computing quantities for excavating rock to a depth of 6 inches below grade and back filling same. In very deep cuts the slopes shall be somewhat flattened and the earthwork figured accordingly.

In making the estimate in the estimate book all computations shall be dated and initialed and standard computation sheets may be inserted and attached to the estimate book. All unit prices shall be supported by subdivided analysis of elements of cost and initialed. Before the estimate is considered complete it will be compared with the standard check list of necessary items in the estimate book to make sure that no item necessary for construction of the project has been omitted.

The final estimate will consist of the sum of the cost of items which fall in three groups:

(1) Excavation of rock and common with allowance for rock overbreak and slides and including the necessary excavation for road intersections of all kinds, borrow, and overhaul.

(2) Clearing and grubbing; also cost of construction of detours, finishing road, etc.

(3) All structures and all surfacing, the structures to include sufficient standard guard rail to protect dangerous curves and all high outside points.

The final estimate shall be carefully entered in the estimate book in ink and initialed, with date, and the title shall show exactly the beginning and ending by stations; also length in miles of the sections for which estimate is made. Too much care in respect to all the features of authority for the estimate can not be taken and, therefore, all unit prices will be initialed.

Location Survey Report.—The chief of party shall make a written report in triplicate to the district engineer of the details of the location survey which he has made, in which report shall be included all pertinent information that does not conveniently lend itself to presentation on the plans or in the estimate. It shall cover the conduct and progress of the work and criticism of same for future use.

The report shall be accompanied by sufficient photographs to present a clear idea of the forest cover, the general character of the country, the special features of drainage, useful existing structures, bridge sites, difficult sections of construction, etc.

The location survey report shall also state carefully the location and nature of all soil or earth through which the surface of the road will pass and which is either (a) suitable for construction of a reasonably acceptable natural soil surface road or (b) not suitable for such construction. The interpretation of the suitability of soils in the report will include the probable number of days of the year for which a road in any given type of soil will with dragging stand up under traffic, and shall carefully describe those portions of the road where soil will not sustain traffic, first, at any time of the year; second, during the spring and late fall; third, during the dry season. The report shall further show in detail a description of the kind and location of all possible gravel surfacing material, rock for structures or surfacing (suitable for crushing or found in slides), sand, timber, etc.

TRACINGS⁵

General.—The outside dimension of all finished tracings will be 22 by 36 inches, with the border line 21 by 33½ inches,

⁵ It is very desirable that before final inking of tracings starts the chief locator or district engineer shall inspect the proposed location with plans in hand and accompanied by the bridge engineer if major structures are involved.

which provides for a 2-inch space to the left for binding. The order of arrangement of numbered sheets of tracings shall be:

1. Title sheet.
2. Sheet of standard cross sections.⁶
3. Plan and profile sheet.
4. Any necessary tables.
5. Structures and any special designing.

The tracings should be neatly and carefully prepared by draftsmen competent to perform satisfactory work. Plans displaying inferior lettering and drafting do not present the required distinctive qualities.

The final transit line shall appear as a medium black line and the final grade as a medium red line. The station numbering on plan and profile shall be sufficiently large to catch the eye and shall be made with a single clean, heavy stroke. Station numbers exceeding two digits need not be given in full except at intervals of 5 or 10 stations, as 510-11-12-13-14-515, etc. At any stationing equation show a stamped hand pointing to same.

Only sufficient curve data for computation with the use of a field handbook need generally be shown on the tracings, although the practice of supplying curve data in tabular form, referring to curves on center line by capital letters, is commendable.

Since the true bearing or azimuth of all courses is recorded in the notebook and checked on the detail-paper office plan, such bearings, where the number of courses becomes excessive, may be traced on the plan only for courses at sufficient intervals to show the general direction of the line and to check with the true north. A north point shall be shown on every sheet. The stations of all points of intersections of transit line or of all points of curvature or points of tangency will appear, except in case of office location from a base-line survey.

There shall appear on the tracing property lines of all parcels of right of way involved, with all necessary dimensions; all land ties and angles of intersecting lines of sufficient importance to appear in topography notes; also names of all

⁶ For the sheet of standard cross sections use print from Vandyke similar to p. 39 or 40. This sheet is to be No. 2 of the plans.

streams and landmarks such as hills, buttes, etc., and the ownership of private land. The following standard shall be used:

Heavy solid lines for forest boundary or county line.

Heavy dot-and-dash for township lines.

Light two-dot-and-dash for section lines.

Light three-dot-and-dash for quarter-section lines.

Light dotted for one-sixteenth section lines.

Light solid for all other lines subdividing property.

Small crosses shall be marked on all fence lines.

Land corners shall be noted as follows:

Authentic corners, by a solid diamond.

Corners not considered authentic, by an open diamond.

Corners searched for but not found, by an open circle.

A legend of the conventional signs used shall be shown.

Do not show, on the tracing, tables of any quantities which are subject to considerable change during construction.

Show on the profile (only) the location, description, and elevation of all bench marks and datum to which elevations are referred, on first sheet of plan and profile. The permanent bench marks must be specially designated. On the profile must be shown elevation of high and low water of streams crossing the line and those immediately adjacent. For the information of the contractor approximate balance points and quantities must be shown on the profile. If it is desired to make grade line on blue prints more pronounced it may be inked red or yellow.

Title Sheet.—The title sheet shall be arranged with respect to scale and disposition of title to allow the layout of the entire project, together with a small vicinity map in the upper left corner and provision for signatures with dates at the lower right. The signatures provided for shall be those of the district engineer, district forester, State highway official (if involved), or county commissioner (if involved). The stations of termini of the project shall appear on the index map. There shall be a notation of scales used and an index of the plans.

GENERAL RÉSUMÉ

These instructions are intended to provide standard procedure for making a staked center line location survey for

national forest roads and to set forth modifications of such methods which may be used when authorized by the district engineer; to describe the method of managing field parties and necessary details of field procedure; and to lay down the standards governing the ultimate development of the field and office plans (including tracings and blueprints), and final estimate. The chief of party will be required, nevertheless, to exercise judgment along the lines of the instructions; he shall display initiative and ability in overcoming difficulties not anticipated in these instructions and take prompt action in notifying the district engineer of unforeseen conditions or emergencies.

As an example, if threatening weather or other conditions require, he may with the help of the transitman and axman push ahead on light work, set the P. I's, and measure angles, leaving the calculation of curve data for the evening and allow the head chainman to set intermediate stakes by eye the day following.

The chief of party will bear in mind that his work is subject to inspection from time to time by an immediate representative of the district engineer, who will act as chief locator and who will be authorized to give necessary directions for improvement of the work in the field.

Special attention is called to the instructions concerning the establishment of permanent bench marks duly referenced with respect to position (which should, if possible, refer to a land survey corner) and elevation, for general cooperative mapping purposes with other branches of the Government. These benches should be shown on the final tracings.

At the close of field operations the chief of party will be responsible for the return or transfer of all property and will immediately turn in to the district engineer's office all field books, plans, papers, etc., with respect to the project.

LOCATION SURVEY EQUIPMENT CHECK LIST

(Including forms listed with general office supplies)

Location engineers or chiefs of party will determine the equipment needed from the following lists.

ENGINEERING EQUIPMENT

- | | |
|--|--|
| <ul style="list-style-type: none"> 1 Y-level, with tripod, hood, and shipping box. 2 100-foot steel tapes. 1 50-foot metallic tape in case. 5 50-foot metallic tape fillers. 2 level rods, one with target and one without target. 1 light 13 or 16 foot single-piece rod. 3 line rods. 1 dozen Eureka or Little Giant tape splices. 2 16-foot rod ribbons. 2 Abney levels with leather cases, latest model. 1 Locke level with leather case. 3 loose-leaf binders with aluminum backs. 2 loose-leaf binders with flexible backs. 300 loose leaves (waterproof for winter use only). 2 field chests with padlocks. 1 transit with tripod, hood, and shipping box. 12 sheets structure paper. 100 quantity sheets. 3 boy scout axes with sheathes. 3 boy's axes with extra handles (2 S. B. axes). 4 double-bitted axes with extra handles (2 D. B. axes). | <ul style="list-style-type: none"> 1 folding draw knife. 2 brush hooks with extra handles. 3 plumb bobs C. I. 10 yards plumb bob string. 1 pound hub tacks (stake tacks). 2 pounds bench-mark nails (10-penny). 1 steel sounding bar kit, specify length and size. 2 pocket compasses. 1 camera with tripod. Films (based on three rolls to mile). 1 Form 99 (photograph exposure record). 1 tool grinder (Champion). 2 cold chisels. 4 whetstones. 1 gad and 1 4½-pound hammer for driving. 2 machetes. 1 saw. 1 tool, saw filing. 2 stake bags. ½ dozen 8-inch flat files. 1 timber scribe. ½ dozen 8-inch files. 1 aneroid barometer. 2 small pack sacks (1 for lunch and 1 for stakes). 1 set standard specifications. 2 wedges, iron-splitting. |
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DRAFTING SUPPLIES

- | | |
|---|--|
| <ul style="list-style-type: none"> 1 folding drawing board for field use. 1 12-inch scale (engineers', flat, 10 by 50). 1 6-inch scale (engineers', flat paragon, K. & E. 1419 P). 2 stools. 1 3-inch scale (engineers', 10 by 60). 1 30°, 18-inch triangle. 1 45°, 24-inch triangle. 1 curve templet. 2 sets drafting instruments (personally owned). | <ul style="list-style-type: none"> 1 slide rule, Mannheim (personally owned). 2 steel straight edges, 30-inch (to fit field chest). 1 T square, 30-inch. 2 protractors, 6-inch radius. 1 French curve. 1 planimeter. 1 Hager & Bonney's tables (personally owned). 1 sheet celluloid for templets. 1 supply chest (wooden). 50 yards profile paper. (This is enough for 68 miles.) |
|---|--|

50 yards detail paper 48 inches wide (roll to be cut at center).	1 bottle orange drawing ink.
100 sheets cross-section paper (thin).	1 bottle blue drawing ink.
3 bottles black drawing ink.	1 bottle red drawing ink.
	1 gasoline office lamp.
	1 parallel rule, 18 inches.

GENERAL OFFICE SUPPLIES






1 dozen 4-H pencils.	100 letterheads.
½ dozen 6-H pencils.	200 sheets paper, 20-pound.
2 dozen 3-H pencils.	300 sheets yellow paper.
1 dozen pencils (Nos. 2 and 3).	100 franked envelopes.
6 pencil clips.	25 franks.
6 penholders.	50 envelopes franked, addressed to district office.
2 dozen Esterbrook pens, No. 802.	1 pad letterheads, ruled.
2 dozen Gillott pens, No. 170.	50 manila franked tags.
2 dozen Gillott pens, No. 303.	1 Corona typewriter.
6 Government bills of lading.	1 rubber stamp with name of project.
1 bottle fountain-pen ink (½ pint).	1 stamp pad.
2 tubes glue (Dennisons).	6 dozen Form 111, daily report (location survey or party cards).
1 box reinforcement rings for loose leaves (100).	2 dozen Form 4A, reimbursement account.
3 diaries.	2 dozen Form 4 inserts.
2 time books.	5 dozen Form 5A vouchers.
1 dozen blotters.	½ dozen Form 61-Rev. (project report).
2 sandpaper pads (pencil pointers).	½ dozen Form FR 3.10-M, distribution.
1 dozen sheets pencil carbon.	1 dozen Form 2-b, field pay roll.
2 I-P binder No. 701.	½ dozen Form 16, pocket requisition form.
1 Triumph punch.	4 dozen Form 500, engineers' report, weekly.
1 box eyelets (same size as Triumph punch).	2 dozen Form 3-A, pay voucher.
1 pair shears, 9-inch.	6 books, Form 4-b, subvoucher.
1 dozen pencil erasers.	3 books, 4-c, party voucher.
½ dozen ink erasers.	1 dozen Form 56-M, office requisition.
2 boxes carbon paper (letter size).	1 pad exemption certificates.
6 scratch pads, small (5 by 8).	1 pad telegraph blanks.
6 scratch pads, larger (8 by 10).	1 book transportation requests.
100 rubber bands, assorted.	3 each accident reports (3 forms).
100 thumb tacks.	10 express charge slips.
5 yards cloth for dust rags and pen wipers.	20 Form PR 1, receipt for nonexpendable property.
4 dozen medium graphite lumber crayon, red and blue (2 dozen each color).	10 Form 161, property lost, destroyed, or stolen.
300 paper clips.	50 Form TM.
12 cardboard backs for filing field notes.	
4 pyramids of pins.	
4 duplicating books.	
20 yards red and white cheese-cloth, 10 yards each.	

50 department Form 15, informal proposal for supplies.	1 gasoline lantern and 12 mantles.
12 Form Sheet D-151 (data required for bridge design).	1 spool flax thread, black.
1 broom.	1 fiscal regulations.
4 chairs, G. M. folding arm (not stools).	1 property regulations.
	1 administrative regulations.

MESS AND CAMP EQUIPMENT

4 wash basins.	1 basting fork.
4 buckets (galvanized water).	1 basting spoon.
1 skimmer, large.	1 funnel.
3 dippers, quart.	24 clothespins.
6 camp kettles, 1½ to 4 gallons (to nest), with covers.	1 cooking range, 4-hole.
1 coffee boiler, 1-gallon.	1 scrub brush.
2 paring knives.	2 wash tubs.
2 carving forks.	6 balls twine.
18 teacups.	1 large griddle (pancake soap-stone).
18 saucers.	2 soup ladles.
1 dishpan, 14-quart.	2 large spoons.
2 dishpans, 17-quart.	18 dinner plates.
1 ½-gallon teapot.	1 whetstone.
18 table forks.	5 yards oilcloth.
18 table knives.	1 hammer.
18 tablespoons.	1 box tacks (carpet).
18 teaspoons.	2 pitchers (1-gallon).
2 meat platters, 16 inches long.	1 grater.
1 cake turner.	2 cupboard boxes.
2 can openers.	6 shakers, small, salt and pepper.
1 washboard.	2 frying pans, 11 inches top diameter.
1 flour sieve.	2 frying pans, 18 inches top diameter.
1 egg beater.	1 butchers steel.
3 bowls, 10 inches diameter.	12 soup bowls.
1 meat saw.	1 broom.
1 No. 2 Universal food chopper.	2 sirup pitchers.
1 spring balance, to weigh 100 pounds.	3 drip pans (size to fit oven).
1 saddle bag, canvas.	12 dish towels (10 yards cotton crash).
1 sailmaker's palm.	1 hand ax.
4 water bags (3 1-gallon and 1 5-gallon).	25 feet wire.
10 G. M. folding cots, No. 1.	1 pliers.
2 butcher knives, 10 and 12 inches.	6 cans Old Dutch cleanser.
15 sauce dishes.	6 hasps.
3 stew pans (5-quart).	

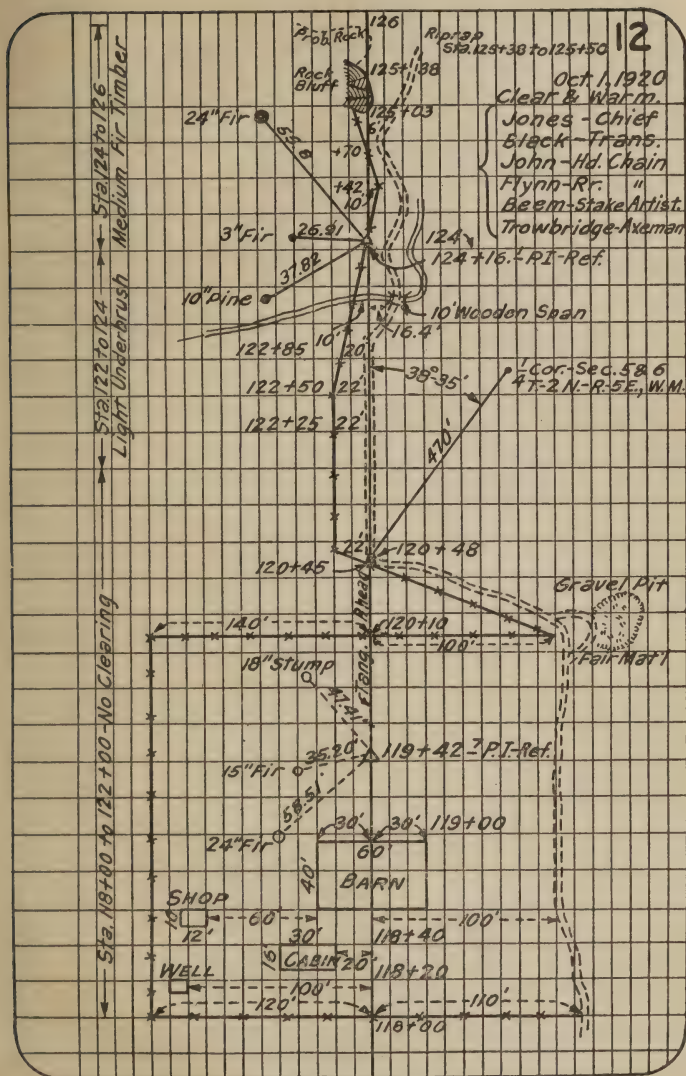
- 2 files.
- 1 screw driver, 12-inch, Perfect handle.
- 12 pounds nails (assorted); 4 pounds 8-penny, 4 pounds 10-penny, 4 pounds 12-penny.
- 1 roller pin.
- 6 padlocks.
- 1 handsaw.
- 1 one-man crosscut saw.
- 1 dining room table with horses (made in field).
- 12 saucers, white enamel, 5½-inch.
- 12 cups, white enamel, coffee, 1-pint.
- 1 kitchen table with horses (made in field).
- 1 14 by 16 tent with flies (5-foot walls) office tent. (This for 8 men only).
- 1 16 by 20 tent, with flies (5-foot walls), mess tent (add 1, 12 by 14, for each 3 additional men).
- 3 12 by 14 tents, with flies (4-foot walls), sleeping tents.
- 1 7 by 9 tent with flies (for cook).
- 1 American flag, 4 by 6.
- 1 Sibley or hot air blast stove for each office and sleeping tent except in midsummer.
- Oil lamps (optional).
- 4 lanterns, oil.
- 6 lantern globes.
- 1 gas lantern with extra mantles for winter work.
- 1 lantern box with pad.
- 1 wagon.
- 100 feet rope, ½-inch.
- 100 feet rope, ¼-inch.
- 1 shovel, long handle.
- 1 pick, railroad, with extra handles.
- 1 sledge, with extra handles, 6-pound.
- 1 first-aid kit.
- 1 frost pin.
- 1 small funnel with gasoline lantern.
- 1 sheet chamois for gasoline lantern.
- 1 Big Ben alarm clock.
- 1 bread board, 20 by 24 inches.
- 1 meat cleaver, 8-inch.
- 6 tin pie plates.
- 100 grocer's 10-pound paper bags.
- 2 1-gallon G. I. flannel covered, zinc screw-top canteen.
- 4 2-quart G. I. flannel covered, zinc screw-top canteen.
- 1 tea kettle (2-gallon), aluminum.
- 1 shoemaker's last.
- 1 shoemaker's hammer.
- 1 dozen cans chloride of lime.
- 1,000 paper napkins.
- 25 yards mosquito netting.
- 1 awl and tool set.
- 6 awls, pegging.
- 2 bags, lunch, canvas, 12 by 14 by 6 inches, with straps.
- 2 bags, book, canvas, 6 by 8 by 3 inches, with straps.
- 1 block, pulley ¼ inch.
- 2 sugar bowls, white enamel.
- 1 colander, 9 inch.
- 1 biscuit cutter.
- 1 doughnut cutter.
- 2 butter dishes.
- Vegetable dishes.
- 3 6-quart stew pans.
- 2 1-gallon pitchers.
- 2 1-pint pitchers.
- 1 potato masher.
- 5 baking pans.

	1st Class	2d Class	3d Class	4th Class
CLEARING	 24" or larger	  24" to 12"	  12" to 4"	Brush
LIGHT	Average spacing of trees --- c. to c.			
	15' or more	20' or more	10' or more	One-half Covered
	10' to 15'	10' to 20'	3' to 10'	Two-thirds Covered
	10' or less	10' or less	3' or less	Completely Covered
MEDIUM				
HEAVY				

Classification of clearing and grubbing for location survey estimate.

Brush includes sage brush, buck brush, scrub oak, etc. Specify kind of timber, as spruce, white pine, Douglas fir. State whether underbrush is mixed with timber. Note areas covered with windfall and standing timber in burnt-over areas. Example of use of table: Trees 12 to 24 inches in diameter with average spacing of 10 to 20 feet. Designate in notes as 2 d M

<i>Sta.</i>	<i>Dist.</i>	<i>Curve Data</i>	<i>(Calculated Course) C.C.</i>	<i>(Magnetic Course) M.C.</i>	<i>Def.</i>
125+63.3 P.T.					+63.3 = 34° 30'
					+50 = 33° 11'
					125 = 28° 11'
		Δ 69° 00' R.			+50 = 23° 11'
124+15.1 P.T.		20° C.R.			124 = 18° 11'
		S.T. 196.9			+50 = 13° 11'
		L. 345.0			123 = 8° 11'
					+50 = 3° 11'
122+18.2 P.C.					
	170.1		N. 50° 10' W.	N. 74° 30' W.	
120+48.1 P.T.					+48.1 = 10° 40'
					120 = 8° 15½'
		Δ 21° 20' R.			
119+42.7 P.T.		10° C.R.			+50 = 5° 45½'
		S.T. 107.9			
		L. 213.3			119 = 3° 15½'
118+34.8 P.C.					+50 = 0° 45½'
			N. 71° 30' W.	S. 87° W.	



Typical transit notes, right page

Sta.	Sept. 30, 1917 - Jordan - Trowbridge - Rod				Elev.
	+	π	-	Rod	
B.M. No. 1					4165.07
	1.49	4166.56			
T.P.			1.90		4164.66
	6.88	4171.54			
0+00				0.5	4171.0
+50				2.1	4169.4
+75				2.0	4169.5
1+00				4.0	4167.5
+50				5.9	4165.6
2+00				7.2	4164.3
+50				8.2	4163.3
3+00				9.2	4162.3
+50				10.3	4161.2
T. P.			6.88		4164.66
	0.75	4165.41 ^v			
4+00				6.8	4158.6
+50				7.5	4157.9
	9.12		8.78		

Typical level and cross section notes, left page

Bloodworth-Notes
Maule-Abney Level
Loock-Rod

Oct. 2, 1917
Warm & Clear

1

Note: - Sections at Hubs to Halve the Interior Angle

24" Fir 70' Left 0+50

+9.12
-8.78
+0.34
4165.07
4165.41

64.0	70.0	71.0	71.5	74.5	76.0	78.0
37	6	00	7	23	35	50
Fence			Roads			

63.9	65.9	69.4	70.9	71.4	72.5	76.4
54	27F	00	5	17	20	45

62.5	66.0	69.5	71.0	71.5	73.0	76.5
54	27F	00	5	17	20	45

58.5	64.5	67.5	69.5	70.5	71.5	74.5
63	21F	00	N	24	26	45

59.6	63.6	65.6	68.6	63.6	69.1	71.1	73.1
45	15F	00	16	20	30	32	50

59.3	63.1	64.3	67.8	68.8	69.8	71.8
45	9F	00	20	34	36	50

59.3	62.3	63.3	66.8	67.8	68.8	73.3
37	7F	00	21	35	37	75

57.8	62.3	62.3	65.8	67.8	68.3	69.8
40	4F	00	25	36	38	50

Abandoned
R.R. Spur

X	56.2	X	61.2	64.7	65.2	66.7	68.7
100	50	5F	00	20	34	36	50

X	54.1	X	58.6	61.6	62.6	64.6	66.6
75RR	45	5F	00	18	32	35	50

54.9	53.4	55.4	X	57.9	60.9	62.4	63.9	67.9
70RR	40	29	5F	00	16	30	34	50



DATA REQUIRED FOR BRIDGE DESIGN

I GENERAL REMARKS

Fill out all blanks carefully giving information on all points listed and supplementary remarks on features not listed. High water and foundation conditions are especially important and should be thoroughly investigated. In the blanks under "RECOMMENDATIONS" give your own opinions and list suggestions of others under "REMARKS"

II PROFILE

Plot profile on $\frac{1}{2}$ of roadway including approach roads affected and connect intersecting roads. Use natural scale, preferably 1" to 10', but not less than 1" to 20'.

At proper location show section of test pits, noting material encountered. Unless on solid rock, foundations in and near stream should extend below liability of scour, and not less than 3 ft. below bed of stream. Test pits should be sunk to at least 6 ft. below bed. If feasible, locate and give character of bed rock.

Show present and if possible, proposed finished grade, noting elevations and gradients.

III MAP

Show present and proposed alignment of bridge and approach es as far as affected. Extend cross-section 30 ft. each side of $\frac{1}{2}$, giving location and elevation of points. Show edge of water, islands, shoals, other obstructions and direction of current at high and low water. Plot location of test pits, position and pointing of camera for each photo, all buildings, fences and other features affected. Establish bench mark and give elevation of same. Reference $\frac{1}{2}$ and show north point.

IV STREAM DATA

- Elev. max. H.W. 44.5 Date Mar. 1919
- Source of information P.C. Magnum R.R. 2.6 mi. N. of Smiths Corner
- If nearest crossing of stream is comparable in size, give section of waterway Mich. C.R.R. bridge 2.6 mi. N. of Smiths Corner
- Elev. normal water 36 Elev. extreme L.W. 34.5
- Est. stream velocity at H.W. 1.5 ft. at L.W. 3 mi. N. of Smiths Corner
- Am't & character of ice & drift left side - light drift
- Do banks or bed show scour? none on bank
- Is stream navigable? No Size of boat
- Est. cost channel change if advisable No change

V GENERAL INFORMATION

- Send photo of bridge site if practicable photos attached
- Is bridge on trunk or secondary road? Main Highway
- Shipping point & dist. from bridge Swansboro 2.6 miles
- Name of R.R. or boat line Mich. C.R.R.
- Condition of road used for hauling good road all year
- Customary load for hauling 3000 Max. load 4000
- Min. clearances along hauling route No unusual conditions

VI LOCAL MATERIALS

- Are following materials available locally? Yes
- (a) Sand Yes Haul 2 mi. Quality good
- Owner Fred. Dwyer Address Smiths Corner, Mich.
- Is screening necessary? No Washing? No
- (b) Gravel Yes Haul 2 mi. Quality good
- Owner Fred. Dwyer Address Smiths Corner, Mich.
- Is screening necessary? No Washing? No
- (c) Stone Yes Haul 2 mi. Quality good
- Owner Harry Grant Address Swansboro, Mich.
- Is stone suitable for cement rubble masonry? Yes

2. Est. cost delivered at bridge site of:

- (a) Sand per cu. yd. 50.00 (b) Gravel per cu. yd. 2.00
- (c) Crushed stone per cu. yd. 2.00 (d) Cement per bbl. 2.00
- (e) Stone for rubble masonry per cu. yd. 2.00

3. Can piling, falsework or hewn timbers be obtained locally? Yes

Tree species White Oak Height & taper 15' x 5" Dia. breast high 14"

Owner Fred. Dwyer Address Smiths Corner, Mich.

4. Dist. from bridge to nearest sawmill, lumber yd. or market where dimension lumber can be obtained 2.6 mi. Species Red Spruce

Price \$40.00 per M. ft. freight rate

5. Is suitable filling material for approaches available? Yes

Haul 1000 ft. Est. cost per cu. yd. in place 20.00

6. Is rock available for rock filled approaches? No

Haul Est. cost per cu. yd. in place

VII RECOMMENDATIONS

- Depth for firm foundation of structure See profile
- Will piling be necessary? Yes
- Clearance above L.W. 125 ft. 4. Total length 112 ft.
- No. of spans 1 @ 40 ft. 6 Length channel span 72 ft.
- Width of roadway 18' 2" 8 Sidewalks 10' ft.
- Type of structure Steel Truss - Concrete floor
- Max. concentrated live load 15 tons

VIII REMARKS

- Area of drainage basin 4.5 sq. miles
- Source of information U.S. Geo. Survey bottom sheets
- Character of drainage basin Hilly, 2 timbered, 2 cleared

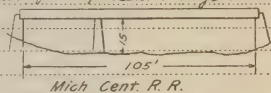
Note: State Highway Engineer suggests

1-70' and 1-36' spans

Note: Old structure to remain in use

until new is completed, therefore no

material from present bridge is available for new



ABBREVIATIONS: Am't = amount, bbl = barrel, cu. yd = cubic yard, dist = distance, elev = elevation, est = estimate, H.W. = high water, L.W. = low water, max = maximum, min = minimum, no = number, photo = photograph, R.R. = railroad

U.S. DEPARTMENT OF AGRICULTURE BUREAU OF PUBLIC ROADS

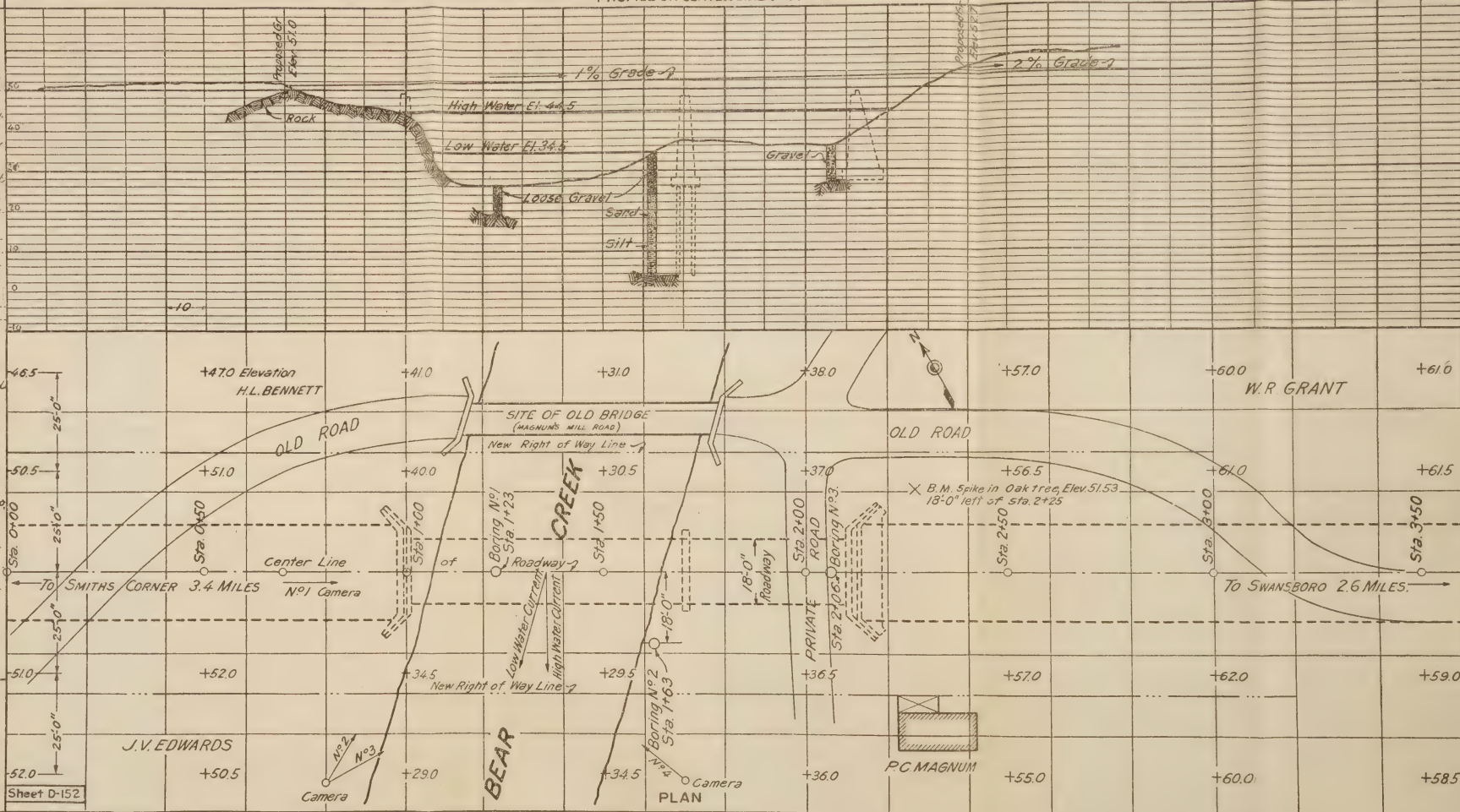
BRIDGE OVER Bear Creek (Magnum's Mill Road)

LOCATION, 3.4 mi. N. of Smiths Corner and Swansboro

COUNTY, Ionia, Mich. STATE, Mich.

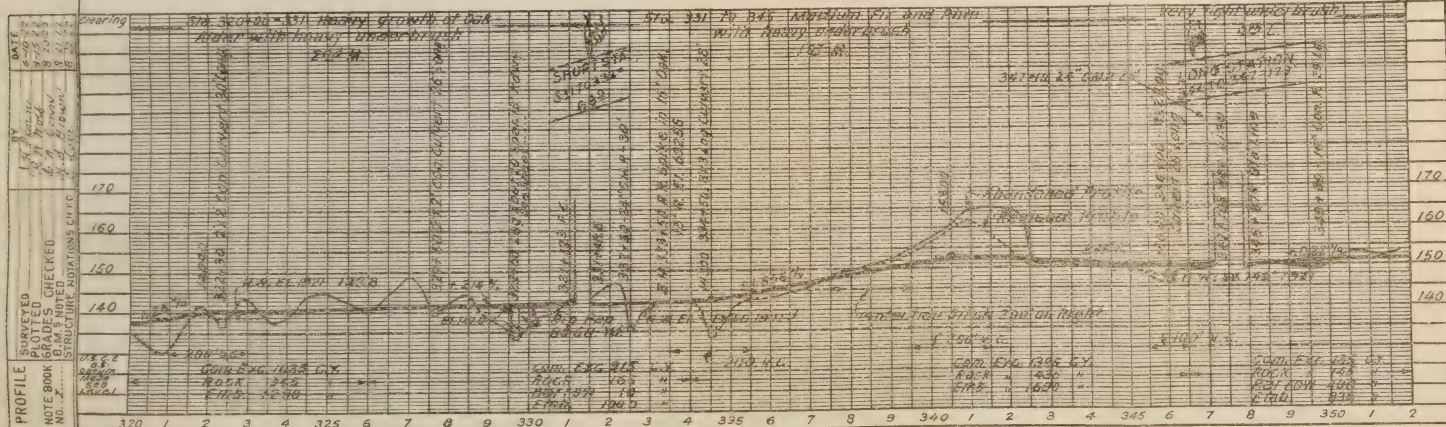
DATE, May 1917. SURVEYED BY J. V. Edwards

PROFILE ON CENTER LINE OF SURVEY



Typical bridge survey sheet

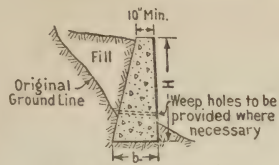
DIST NO	STATE	PROJ NO	SEC NO	SHEET NO	TOTAL SHEETS
1	ORE	510	1	4	24



95762°—26. (Follows p. 37.) No. 2



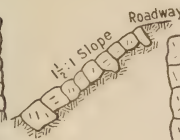
DRY RUBBLE MASONRY



CEMENT RUBBLE MASONRY OR CONCRETE (CLASS C' OR D') RETAINING WALLS



RIP RAP (Hand Laid)



STONE GUARD FENCE - TYPE 1

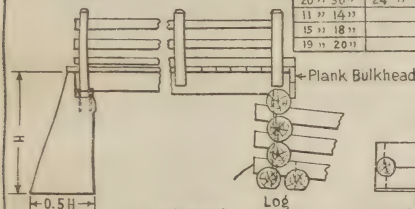
END ELEVATION

STRINGERS

SPAN	LOGS	SAWED TIMBER
8 TO 10 FT	1 1/2" diam.	4" x 12"
10 " 12 "	1 1/2" "	4" x 12"
12 " 17 "	1 1/2" "	4" x 12"
17 " 20 "	2 1/2" "	4" x 12"
20 " 30 "	2 1/2" "	4" x 12"
11 " 14 "	1 1/2" "	4" x 14"
15 " 18 "	1 1/2" "	4" x 16"
19 " 20 "	1 1/2" "	6" x 16"

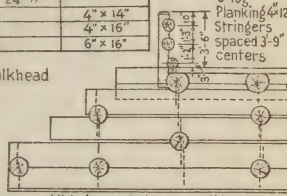
Railing posts
8' logs
Rails 6' logs
Felloe guard
6' logs
Planking 4' x 12'
Stringers spaced 3'-9" centers

Rail posts 6' x 6'
Rails 3' x 8'
Felloe guard
4' x 6'
Planking 4' x 12'
Stringers spaced 2'-0" centers



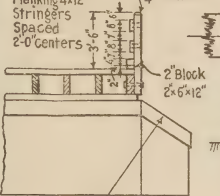
Sawed Timber on Masonry Abutment

ELEVATION

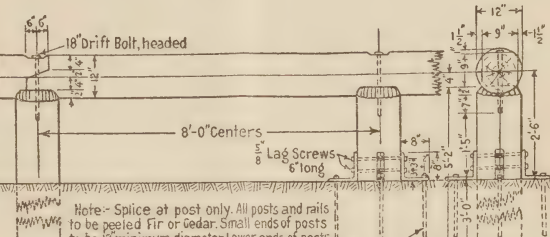


All logs are to be thoroughly fastened together with 3/4" drift bolts

SECTION

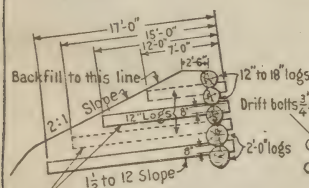


Wings to flare back as required to suit field conditions



Note:- Splice at post only. All posts and rails to be peeled Fir or cedar. Small ends of posts to be 12" minimum diameter. Lower ends of posts to be charred or well treated with carbolineum to a point 8" above the ground line. Diameter of rails to be between 12" and 14". Tops of posts to be hewn as shown. When fence rests on solid rock use iron plates as shown (2' x 16' x 1/2")

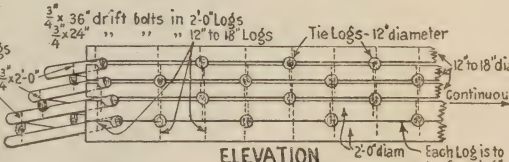
RUSTIC GUARD FENCE - TYPE 2



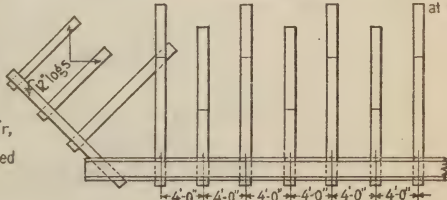
Block up ends until fill is made

TYPICAL SECTION

Notes:-
Ends to flare back as required to suit field conditions.
All logs are to be sound cedar or fir, with all bark removed.
The wall is to be thoroughly drift bolted as shown. All drift bolts 3/4" Fill to be rock.

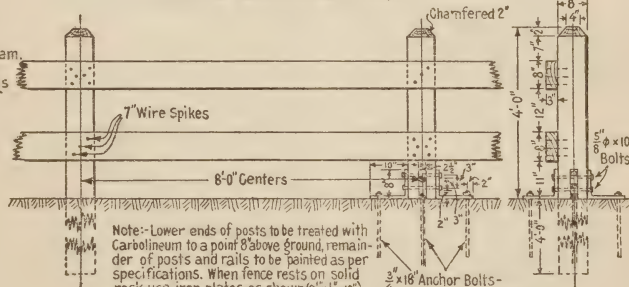


ELEVATION



PLAN

LOG DIVERTING DAM



Note:- Lower ends of posts to be treated with Carbolineum to a point 8" above ground, remainder of posts and rails to be painted as per specifications. When fence rests on solid rock use iron plates as shown (2' x 16' x 1/2") Posts 8' x 8'-5.4.8. Rails 3' x 8'-5.4.8.

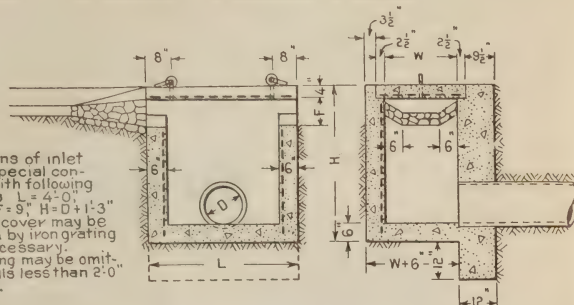
WOODEN GUARD FENCE - TYPE 3

**U.S. BUREAU OF PUBLIC ROADS
MISCELLANEOUS**

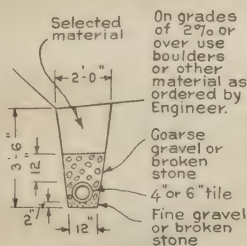
STANDARD STRUCTURES

Note:

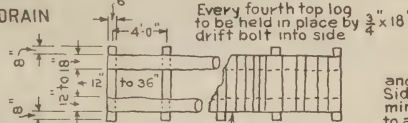
Dimensions of inlet vary to special conditions with following minimums: $L=4'-0"$, $W=2'-0"$, $F=9"$, $H=D+1'-3"$. Concrete cover may be replaced by iron grating where necessary. Reinforcing may be omitted in walls less than 2'-0" in height.



CONCRETE DROP INLET FOR PIPE CULVERT



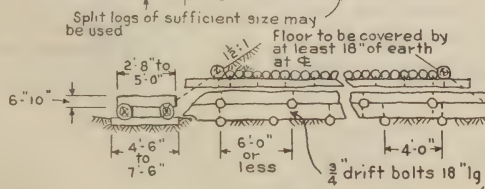
TILE UNDERDRAIN



DRY RUBBLE HEADWALL

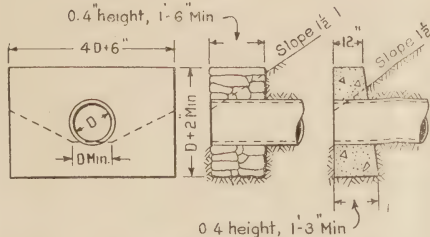
Every fourth top log to be held in place by $\frac{3}{4}$ " x 18" drift bolt into side.

All logs to be of sound cedar, where ever obtainable, or fir; all bark to be removed. Top logs to be 6" to 10" diam, hewed to at least a 3" face on 3 sides or unsurfaced 3" on 2 sides and notched on ends of third side. Side logs to be hewed on 2 sides, 3" min. for ample bearing and notched to a depth of 1" at each mud sill and 2" at each tie log. Mud sills to be not less than 6" diam and notched to a depth of 1" to receive side logs. Tie logs to be at least 8" in diam. and notched to a depth of 2" on top and bottom to receive side logs. Tie logs to extend 3' to 5' into embankment.

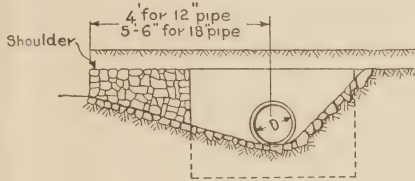


LOG CULVERTS

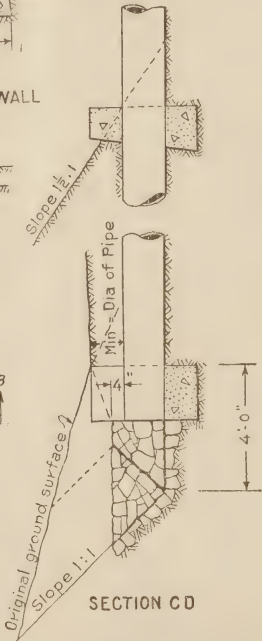
Span 1 to 6 ft.



CONCRETE OR CEMENT RUBBLE HEADWALL



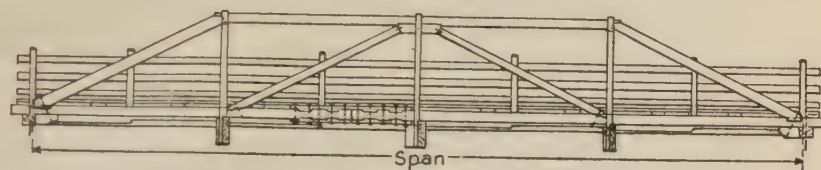
PAVED INLET



SECTION CD

U.S. BUREAU OF PUBLIC ROADS

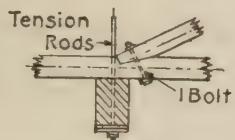
STANDARD PIPE AND LOG CULVERTS



ELEVATION



"Bent Plate"



INTERMEDIATE JOINT
"Framed"



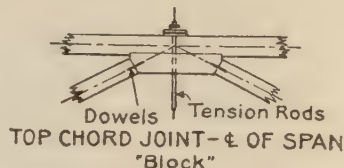
INTERMEDIATE JOINT
"Angle"



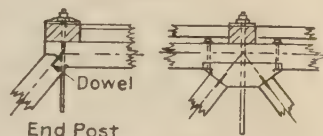
Cast Iron Shoe



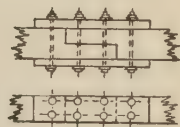
"Bent Plate & Block"



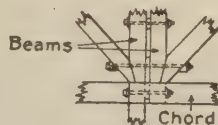
TOP CHORD JOINT- $\frac{1}{4}$ OF SPAN
"Block"



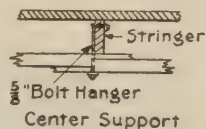
TOP CHORD JOINTS



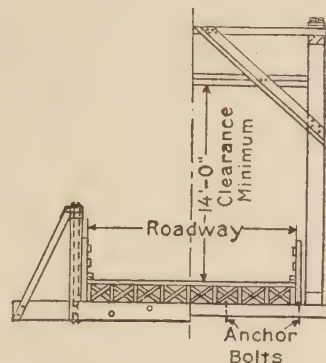
TOP CHORD SPLICE



LOWER LATERAL CONNECTIONS



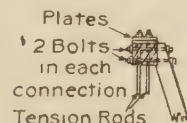
Center Support



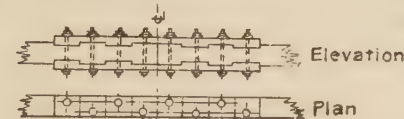
PONY SPAN SECTION
THROUGH SPAN END ELEVATION



OUTRIGGER

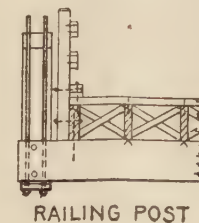


OUTRIGGER
(Alternate)



LOWER CHORD SPLICE

Note:- Splice timber is to be No.1 clear, structural grade. All surfaces must be thoroughly painted, according to specifications, before assembling. Splice pieces must be of full thickness and framed with square shoulders and with all surfaces in full contact.



RAILING POST

CAMBER DIAGRAM

Note:- Camber at each panel point as given on diagram is to be provided for both in framing truss members and by blocking during erection

NOTES

All bearings, especially framed joints to have full uniform bearing on all surfaces, no clearances to be allowed.

All surfaces in contact to be painted with carbolineum before assembly and all lumber in contact with either earth or masonry should preferably be treated with carbolineum or creosote.

Railings are to be of surfaced lumber and painted white in conformity to U.S.B.P.R. specifications.

All truss rods are to be tightened up to give initial tension in each and so adjusted that each rod at any panel point shall have the same tension.

After adjustment all nuts are to be effectively checked and exposed threads should be coated with white lead or graphite paint.

All lumber must be selected for the particular requirements of each part of the structure.

Cast iron or cut washers are to be used under all bolt heads and nuts.

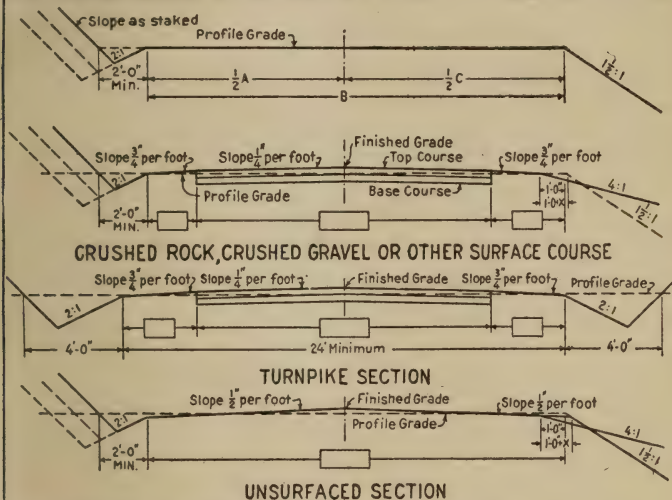
U.S. BUREAU OF PUBLIC ROADS
TYPICAL TYPES
HOWE TRUSS FRAMING

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS
STANDARD CROSS SECTION
FOREST HIGHWAYS
AS REVISED FOR 1926 CONSTRUCTION

DISTRICT NO. STANDARD ROADWAY
PROJECT
NATIONAL FOREST
COUNTY
STATE

Standard Roadways are as designated in the table and imply the corresponding dimensions shown in the table.

STANDARD ROADWAY	DIMENSIONS				
	CUT A	SIDEHILL B	FILL C	$\frac{1}{2}$ A	$\frac{1}{2}$ C
12	16	17	18	8	9
14	18	19	20	9	10
16	20	21	22	10	11
18	22	23	24	11	12



All curves are to be widened and superelevated as per instructions.

Where drainage conditions require larger side ditches the necessary widening shall be done.

In thru cuts on sidehill location where there will be little drainage to care for, the outside

three (3) foot shoulder of the adjacent fill shall be carried through with a one (1) foot ditch;

In cuts on rolling terrain and light grading carry through the three (3) foot shoulders of

the adjacent fills with additional side ditches as necessary for drainage conditions.

Increase or decrease thickness of surfacing as local conditions may require.

CRUSHED ROCK
OR
CRUSHED GRAVEL
(OR OTHER SURFACE COURSE)
(As per Specifications)
One Course ---- inches
Top Course ---- inches
Base Course ---- inches

APPROVED _____ DATE _____
CHIEF ENGINEER

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS
STANDARD CROSS SECTION
MAJOR FOREST DEVELOPMENT ROADS
AS REVISED FOR 1926 CONSTRUCTION

DISTRICT NO. STANDARD ROADWAY

PROJECT

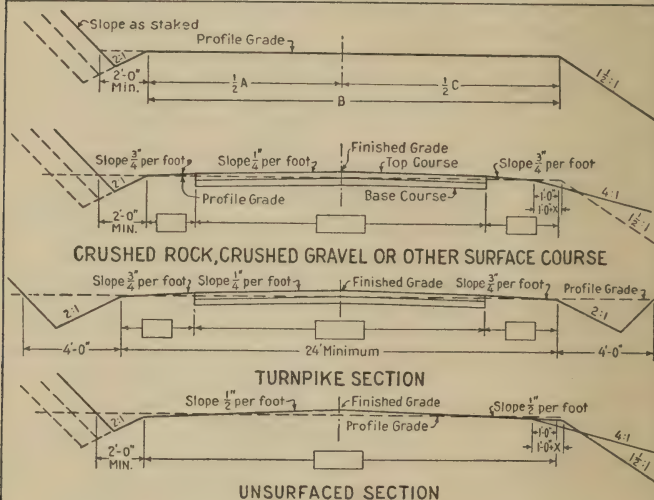
NATIONAL FOREST

COUNTY

STATE

Standard Roadways are as designated in the table and imply the corresponding dimensions shown in the table.

STANDARD ROADWAY	DIMENSIONS				
	CUT A	SIDEHILL B	FILL C	$\frac{1}{2}$ A	$\frac{1}{2}$ C
8	12	13	14	6	7
12	16	17	18	8	9
14	18	19	20	9	10
16	20	21	22	10	11
18	22	23	24	11	12



All curves are to be widened and superelevated as per instructions.
Where drainage conditions require larger side ditches the necessary widening shall be done.
In thru cuts on sidehill location where there will be little drainage to care for, the outside three(3) foot shoulder of the adjacent fill shall be carried through with a one (1) foot ditch.
In cuts on rolling terrain and light grading carry through the three(3) foot shoulders of the adjacent fills with additional side ditches as necessary for drainage conditions.
Increase or decrease thickness of surfacing as local conditions may require.

CRUSHED ROCK
OR
CRUSHED GRAVEL
(OR OTHER SURFACE COURSE)
(As per Specifications)
One Course --- Inches
Top Course --- Inches
Base Course --- Inches

APPROVED _____ DATE _____
CHIEF ENGINEER

Standard cross sections for major forest development roads

ADDITIONAL POINTS

To comply with recommendations of the subcommittee on Control of the Board of Surveys and Maps of the various Federal Department, the following additional instructions will be followed:

1. Where possible use as reference marks for transit points a spike driven through a metal washer outside the zone of disturbance and as near on level with final grade of P. I. as may be.

2. Mark permanently by iron pin not less than 1 inch in diameter, or by equivalent marker, beginning and end of each survey and triple reference same.

3. Where possible, without undue expense, tie beginning and end of every survey to any existing surveys in the vicinity, and mark junction point as directed under 2, and determine and record the angle of intersection of the two lines.

4. Calculated bearings recorded for check on plans shall be true bearings. Show both true north point and magnetic deflection on each sheet of finished tracing.

5. Show on tracing stationing of both ends of all important bridges built or to be built on the line.

6. In coast country reference levels also to any United States Geodetic Survey bench available; secure in advance bulletin from Geodetic Survey or Geological Survey in Washington for spirit level results in the State in which survey is made to facilitate determination of true elevations, and secure also in advance necessary tables or data for determining true north from Polaris or the sun.

AMENDMENTS

These instructions may from time to time be amended and in such instances you will be furnished the necessary corrections to be inserted as a part of these instructions.



